Treatment Options
Part 1

Tom Sorg
Darren Lytle

Water Supply and Water Resources Division
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH

Topics – Part 1

- **Arsenic Chemistry**
- BAT Technology
- Adsorptive Media

Arsenic Chemistry

Arsenic Species

As (III) - **$H_3AsO_3^0$** , $H_2AsO_3^{-1}$, $HAsO_3^{-2}$

As (V) - $H_3AsO_4^0$, **$HAsO_4^{-1}$** , **AsO_4^{-2}**

Arsenic Chemistry

What is the significance of arsenic speciation?

As V more effectively removed than As III by most treatment technologies

Arsenic Occurrence

Surface waters - predominantly As (V)

Ground waters – usually found as As (III), however, it can As (V) or a combination of As (III) and As (V).

Arsenic Chemistry

For maximum As removal

oxidize As (III) to As (V)

before applying treatment

As III Oxidation

Effective!

- **Free Chlorine**
- **Potassium Permanganate**
- **Ozone**
- **Solid Oxidizing Media** **(MnO_2 solids)**

Ineffective

- **Chloramine**
- **Chlorine Dioxide**
- **UV Radiation**

Oxidation of As III by aeration

not effective

Topics – Part 1

- Arsenic Chemistry
- **BAT Technology**
- Adsorptive Media

Arsenic Rule

Best Available Technology (BAT)

Technology	Maximum Percent Removal (As V)
Ion Exchange	95
Activated Alumina	90
Reverse Osmosis	>95
Modified Coag/Filtration	95
Modified Lime Softening	80
Electrodialysis Reversal	85
Oxidation/Filtration (20:1 Fe/As)	80

Arsenic Rule

Other Ground Water Processes

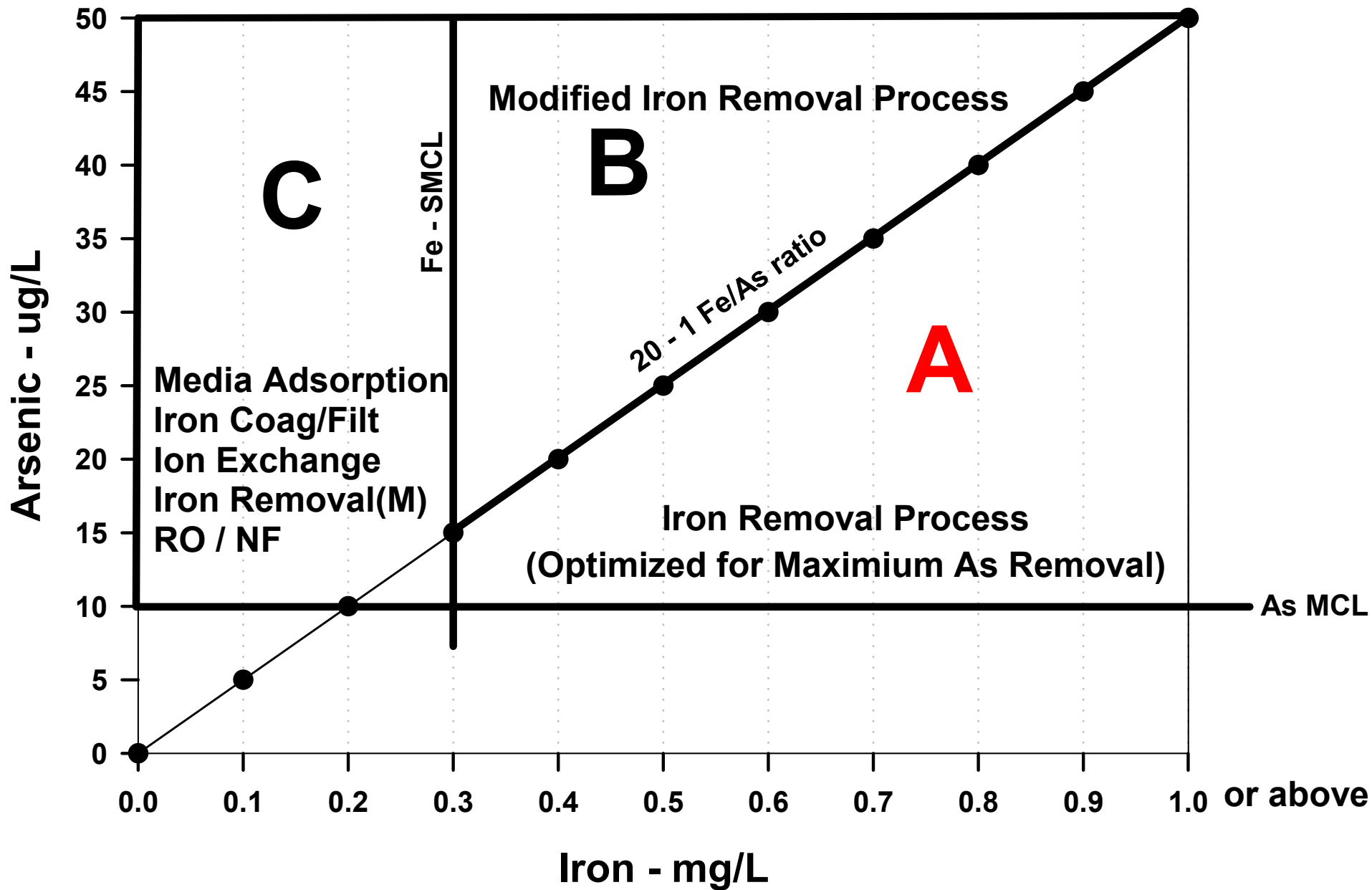
Technology	Reason for not being listed as BAT
Coagulation Assisted Microfiltration	No full scale history
Granular Ferric Hydroxide (GFH)	Lack of published data

Arsenic Rule

Small Systems Compliance Technologies

- Centralized Treatment – IE, AA, MC/F, MLS, Fe Removal
- POU - RO, Activated Alumina
- POE – Activated Alumina

Arsenic Treatment - Process Selection Guide



Topics – Part 1

- Arsenic Chemistry
- BAT Technology
- **Adsorptive Media**

Arsenic Demonstration Program – Round 1

Technologies selected for demonstration (12 sites)

Adsorptive media – 9

- Iron media – 7 (E 33, Sorb 33, GFH)
- Iron based media – 1 (G2)
- Modified activated alumina –1 (AAFS 50)

Ion exchange – 1 (As & NO_3)

Iron removal – 1

Treatment modification (iron removal process) - 1

Adsorptive Media Processes

Advantages

- Simple process
- High removal capacity
- Non hazardous waste products
- Low cost

Adsorptive Media Treatment

Disadvantages

- Removal capacity impacted by water chemistry, such as pH
- pH adjustment may be required
- Media replacement

Adsorptive Media Treatment

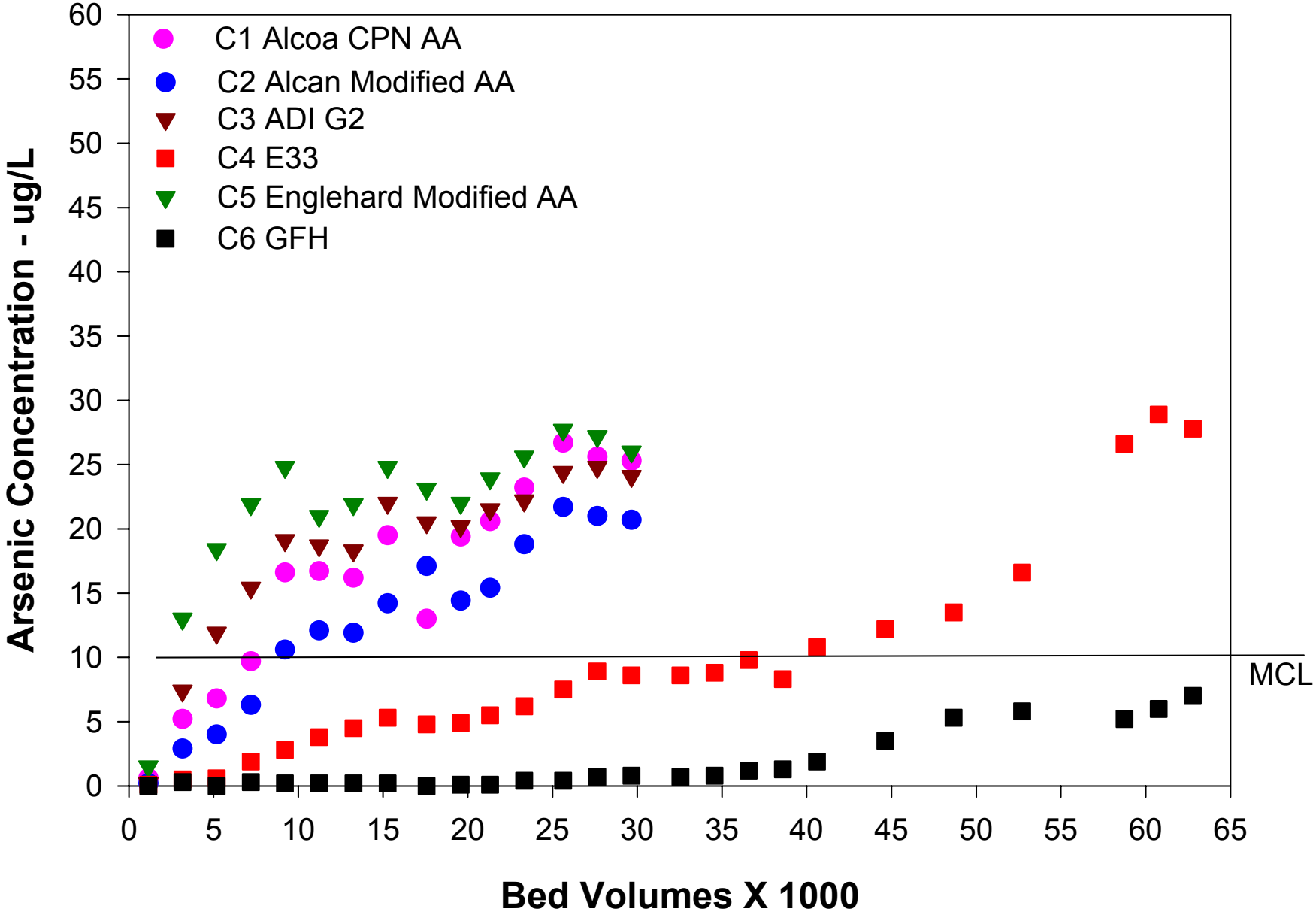
Key design factors

- Media
- Bed configuration

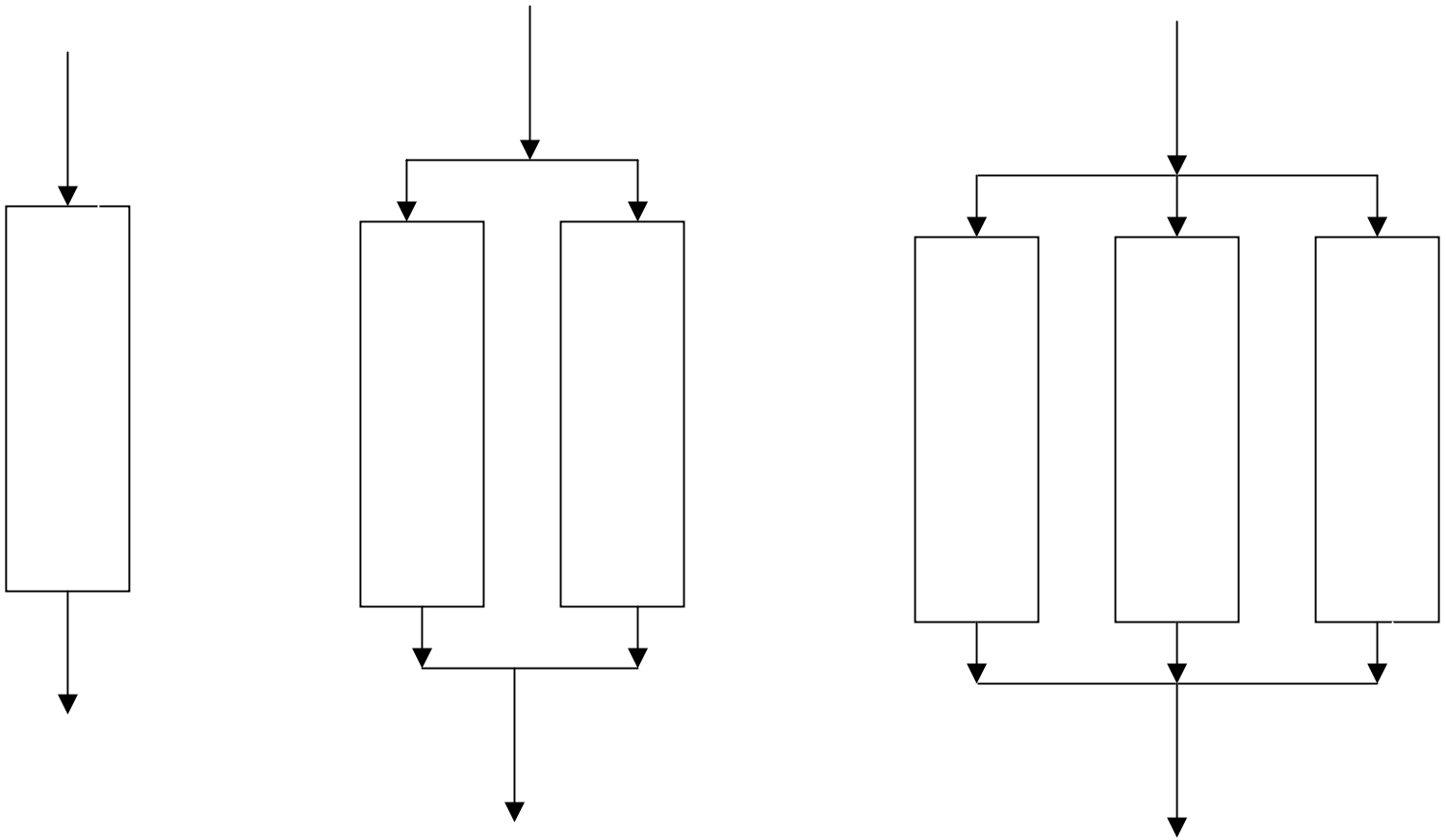
Adsorptive Media Listed in NSF/ANSI STD 61

Company	Base Material	Name	Material
Alcan (4)	Aluminium	AAFS - 50	Mod AA
Alcoa (2)	Aluminium	CPN	AA
Apyron	Aluminium	Aqua-Bind	Mod AA
Engelhard	Aluminium	ARM 100	AA
Engelhard	Iron	ARM 200	Iron Oxide
ADI Internat.	Iron	G2	Iron based
SMI	Iron	SMI III	Iron/sulfur
US Filter	Iron	GFH	Iron Hydroxide
Bayer AG	Iron	E 33	Iron Oxide
WRT	Zeolite	Z – 33	Mod Zeolite
Magnesium Elektron	Zirconium	Isolux	Zirconium Hydroxide

Figure 1. Results of Arsenic Removal by Adsorptive Media Pilot Plant Studies.

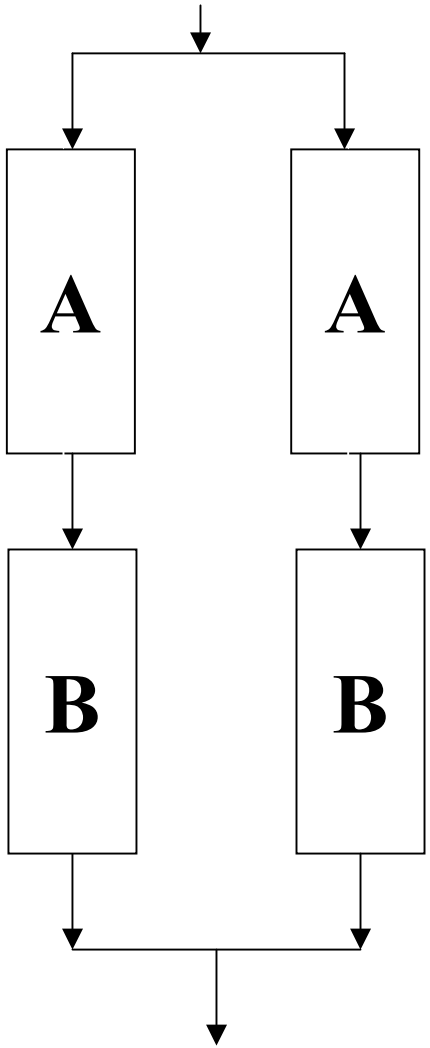


Adsorptive Media System Designs



Simple 1, 2, or 3 beds in parallel

Adsorptive Media System Design



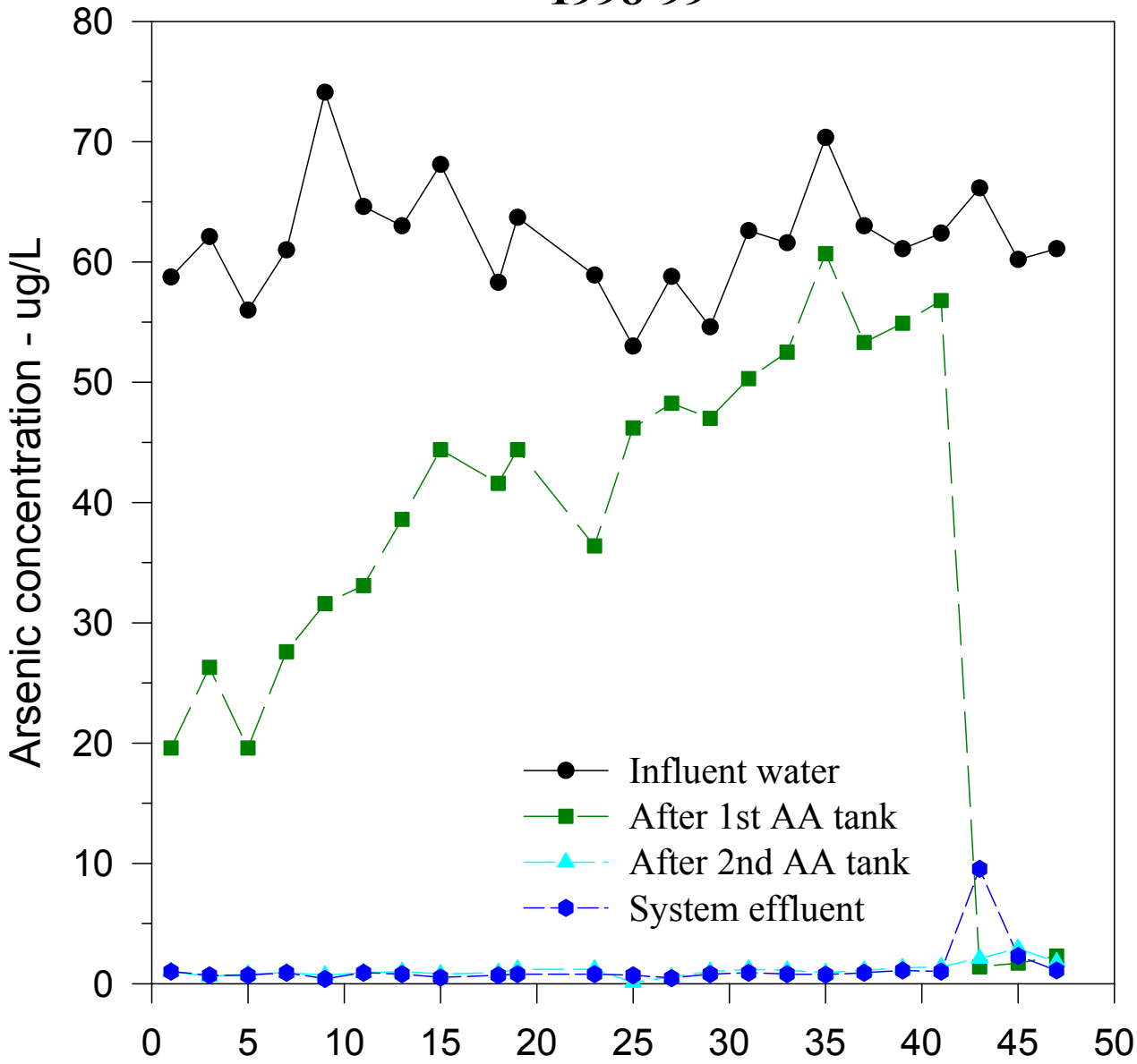
Roughing filter

Polishing filter

Series Design

Activated Alumina System - New Hampshire

Arsenic Removal, Activated Alumina System(CS), NH. 1998-99



Influent water: pH 8.2, alk 58 mg/L ($CaCO_3$), Fe <0.03 mg/L

Adsorptive Media Treatment

Flow gpm	Media	Design	Total Capital Investment (TCI)	Equipment Cost	Eq Cost % of TCI
70	G2	Series	$154,700	$102,600	66
37	AAFS50	Series	$228,309	$122,646	54
45	E33	Series	$90,757	$66,235	73
100	E33	Parallel	$106,568	$82,081	77
145	E33	Parallel	$139,251	$112,211	80
300	E33	Parallel	$211,000	$129,500	62
320	E33	Parallel	$153,000	$112,600	73
350	GFH	Parallel	$232,309	$157,646	68
640	E33	Parallel	$305,000	$218,000	71